NASA/DoD Aerospace Knowledge Diffusion Research Project

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A Comparison of the Technical Communication Practices of Aerospace Engineers and Scientists in India and the United States
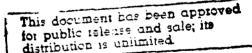
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INTRODUCTION

Rapidly changing patterns of international cooperation and collaboration and revolutionary technological and managerial changes are combining to influence and transform the communication of technical information in the workplace. To contribute to our understanding of workplace culture, organization, and communications at the national and international levels, an exploratory study was conducted that investigated the technical communications practices of aerospace engineers and scientists at two research organizations, one in India and the other in the United States (U.S.). Previous work includes exploratory studies of the technical communications practices of aerospace engineers and scientists in Israel [1], Japan [2][3], selected Western European countries [4], Russia [5], the Netherlands [6], and the U.S. [7][8].

The data reported herein were collected through self-administered questionnaires undertaken as a Phase 4 activity of the *NASA/DoD Aerospace Knowledge Diffusion Research Project*. The India/U.S. study included the following objectives:

1. To solicit the opinions of aerospace engineers and scientists regarding the importance of technical communications to their profession,

2. To determine the use and production of technical communications by aerospace engineers and scientists,

3. To seek their views about the appropriate content of an undergraduate course in technical communications,

4. To determine their use of libraries and technical information centers,

5. To determine their use and the importance of computer and information technology to them,

6. To determine their use of electronic networks, and

7. To determine their language (ability to read and speak) skills and their use of foreign and domestically produced technical reports.

BACKGROUND

Aerospace engineering exhibits particular characteristics which make it an excellent platform for studying technical communications in the international workplace. The aerospace industry is becoming more international in scope and increasingly collaborative in nature, thus creating a multinational manufacturing environment. International industrial alliances will result in a more rapid diffusion of technology in order to enhance innovation and increase productivity. Aerospace producers will feel growing pressure to push forward with new technological developments, to maximize the inclusion of those developments into the research and development (R&D) process, and to maintain and improve the professional competency of aerospace engineers and scientists. Meeting these objectives at a reasonable cost depends on a variety of factors, but largely on the ability of aerospace engineers and scientists to acquire, process, and communicate scientific and technical information (STI). Although studies indicate that access to STI can increase productivity and innovation and help aerospace engineers and scientists maintain and improve their professional skills, these same studies demonstrate that little is known about how aerospace engineers and scientists find and use STI or how aerospace knowledge is diffused. To learn more about this process, researchers at the NASA Langley Research Center, the Indiana University Center for Survey Research, Rensselaer Polytechnic Institute, and institutions in selected countries are studying aerospace knowledge diffusion. These studies comprise the *NASA/DoD Aerospace Knowledge Diffusion Research Project.* A project fact sheet appears in Appendix A.

Phase 1 of the project investigates the information-seeking behavior of U.S. aerospace engineers and scientists and places particular emphasis on their use of federally funded aerospace

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R&D and U.S. government technical reports. Phase 2 examines the industry-government interface and emphasizes the role of information intermediaries in the aerospace knowledge diffusion process. Phase 3 concerns the academic-government interface and focuses on the relationships between and among the information intermediary, faculty, and students. Phase 4 explores patterns of technical communications among non-U.S. aerospace engineers and scientists in selected countries [9]. A list of *NASA/DuD Aerospace Knowledge Diffusion Research Project* publications appears in Appendix B.

RESEARCH DESIGN AND METHODOLOGY

The research was conducted at comparable research facilities: the Indian Institute of Science (IIS) in Bangalore, India and the NASA Langley Research Center (Hampton, VA) in the U.S., using self-administered (self-reported) mail surveys. The instrument used to collect the data had been used previously in several Western European countries and Japan and in the Netherlands and Russia in slightly adapted form. English-language questionnaires were distributed to 150 researchers at the IIS and 72 were received by the established cut off date for a completion rate of 48 percent. Questionnaires were distributed to 383 researchers at the NASA Langley Research Center and 150 were received by the established cut off date for a completion rate of 53 percent. The survey at the IIS was conducted during March and June of 1993, and the survey at the NASA Langley Research Center was conducted during July and August of 1992 with a follow-up in December 1992. The survey instruments used in India and the U.S appear in Appendixes C and D, respectively.

PRESENTATION OF THE DATA

This report presents selected results from the India and U.S. studies, with the India responses presented first, followed by the U.S. responses. Demographic data are presented first, followed by data dealing with the importance of technical communications, workplace use and production of technical communications, appropriate course content for an undergraduate course in technical communications, use of libraries and technical information centers, use of computer and information technology, use of electronic networks, and use of foreign and domestically produced technical reports.

Demographic Information About the Survey Respondents

Survey respondents were asked to provide information regarding their professional duties, years of professional work experience, educational preparation, current professional duties, and gender. These demographic findings appear in table 1. A comparison of the two groups reveals more differences than similarities. The two groups differ significantly in terms of organizational affiliation, gender, amount of education, and current professional duties; they are similar in years of professional work experience, academic preparation, and professional society membership.

The following "composite" participant profiles were based on the demographic data. The India survey participant works as a researcher (62%), has a graduate degree (93%), was trained as an engineer (76%) and currently works as a scientist (54%), has as an average of 20 years professional work experience, and is a member of a professional/technical society (85%). The U.S. survey participant works as a researcher (88%), has a graduate degree (72%), was trained as an engineer (86%), currently works as an engineer (75%), has an average of 18 years of professional work experience, and belongs to a professional/ technical society (85%).

Table 1. Demographic Findings

Demographics	India		U.S.	
	%	(n)	%	(n)
Professional Duties				
Design/Development	31	(22)	1	(2)
Administration/Management	6	(4)	11	(16)
Research	62	(44)	88	(132)
Other	1	(1)	0	(0)
Organizational Affiliation				
Academic	27	(19)	0	(0)
Government	63	(52)	100	(150)
Professional Work Experience				
1 - 5 years	0	(0)	17	(25)
6 - 10 years	17	(12)	13	(20)
11 - 20 years	44	(31)	29	(44)
21 - 40 years	39	(28)	40	(59)
41 or more years	0	(0)	1	(2)

	India	U.S.
Mean	20	18
Median	20	17

Demographics	India		U.S.	
Education				
Bachelor's Degree Or Less	7	(66)	28	(42)
Graduate Degree	93	(5)	72	(108)
Educational Preparation				
Engineer	76	(54)	86	(129)
Scientist	24	(17)	10	(15)
Other	0	(0)	4	(6)
Current Duties				
Engineer	39	(28)	75	(113)
Scientist	54	(38)	20	(30)
Other	7	(5)	5	(7)
Member of A Professional/				
Technical Society	85	(60)	76	(24)
Gender				
Female	6	(4)	19	(28)
Male	94	(67)	81	(122)

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Survey respondents were also asked to provide information about their foreign language skills, specifically their reading and speaking competencies in the languages used by major international aerospace producers. These findings appear in table 2. The India respondents read and speak English. Both India and U.S. respondents reported limited fluency in foreign languages. Both groups reported little fluency in either Japanese and Russian. The mean ($\bar{X}$) ability to read and speak French, German, and Japanese was higher for India than for the U.S. group. The mean ($\bar{X}$) ability to read and speak Russian, although low for both groups, was higher for the U.S. group.

Table 2. Foreign Language Fluency Among India and U.S.
Aerospace Engineers and Scientists

Language	India n = 71			U.S. n = 150		
	Read %	Speak %	$\bar{X}$ Ability[a]	Read %	Speak %	$\bar{X}$ Ability[a]
English	100	100	4.9 4.9	100[b]	100[b]	---- ----
French	13	10	2.8 2.9	32	17	1.5 1.5
German	40	30	2.4 2.3	23	11	1.4 1.3
Japanese	1	4	3.0 1.7	1	2	1.0 1.0
Russian	1	0	1.0 0.0	7	4	1.3 1.2

[a] A 1 to 5 scale was used to measure ability with "1" being passably and "5" being fluently; hence, the higher the average (mean) the greater the ability of survey respondents to speak/read the language.

[b] English is the native language for these respondents.

Importance of and Time Spent on Technical Communications

Approximately 88% of the India respondents and 89% of the U.S. respondents indicated that the ability to communicate technical information effectively is important. (Importance was measured on a 5-point scale with 1 = very unimportant and 5 = very important; percentages = combined "4" and "5" responses.) The India aerospace engineers and scientists spent an average of 18.04 hours per week communicating technical information to others; U.S. aerospace engineers and scientists spent

an average of 15.27 hours per week. India aerospace engineers and scientists spent an average of 11.68 hours per week, and U.S. aerospace engineers and scientists spent an average of 13.20 hours per week working with communications received from others (table 3). Considering both the time spent communicating information with others and working with communications received from others, technical communications takes up approximately 74% of the India aerospace engineer's and scientist's 40-hour work week and 71% of the U.S. aerospace engineer's and scientist's work week.

Approximately 83% of the India respondents and 69% of the U.S. respondents indicated that the amount of time they spent communicating technical information had increased over the past 5

Table 3. Mean (Median) Number of Hours Spent Each Week By India and U.S.
Aerospace Engineers and Scientists Communicating Technical Information

Communication Activity	India	U.S.
Communication With Others	18.04 (17.00) hours/week	15.27 (14.00) hours/week
Working with Communications Received From Others	11.67 (10.00) hours/week	13.20 (12.00) hours/week
Percent Of Work Week Devoted To Technical Communications*	74%	71%

*Based on a 40-hour work week.

years (table 4). Fourteen percent of the India respondents and 25% of the U.S. respondents indicated that the amount of time they spent communicating technical information had stayed the same over the past 5 years. Only 3 percent of the India respondents and 6% of the U.S. respondents indicated that the amount of time they spent communicating technical information had decreased over the past 5 years.

Table 4. Changes in the Past 5 Years in the Amount of
Time Spent Communicating Technical Information by
India and U.S. Aerospace Engineers and Scientists

	India		U.S.	
Change	%	(n)	%	(n)
Increased	83	(59)	69	(103)
Stayed The Same	14	(10)	25	(38)
Decreased	3	(2)	6	(9)

As they have advanced professionally, 75% of the India respondents have increased the amount of time they spend communicating technical information. Likewise, 69% of the U.S. respondents indicated that, as they have advanced professionally, they have increased the amount of time they spend communicating technical information (table 5).

Table 5. Changes in the Amount of Time Spent Communicating Technical
Information as a Part of Professional Advancement by
India and U.S. Aerospace Engineers and Scientists

	India		U.S.	
Change	%	(n)	%	(n)
Increased	75	(53)	69	(104)
Stayed The Same	21	(15)	22	(33)
Decreased	5	(3)	9	(13)

The Production and Use of Technical Communications

The process of collaborative writing was examined as part of this study. Survey participants were asked whether they wrote alone or as part of a group (table 6). Approximately 10% of the India respondents and 13% of the U.S. respondents write alone. Although a slightly higher percentage of India than the U.S. respondents writes with a group of 2 to 5 persons or with a group of more than 5 persons, writing appears to be a collaborative process for both groups.

Table 6. Collaborative Writing Practices of India and U.S.
Aerospace Engineers and Scientists

Collaborative Practices	India			U.S.		
	$\overline{X}\%$	%*	(n)	$\overline{X}\%$	%*	(n)
I Write Alone	49.4	10	(7)	56.9	13	(19)
I Write With One Other Person	24.7	76	(54)	21.3	73	(110)
I Write With A Group Of Two To Five People	21.4	73	(52)	18.6	65	(97)
I Write With A Group Of More Than Five People	4.5	17	(12)	3.2	15	(23)

* Percentages do not total 100

India and U.S. aerospace engineers and scientists were asked to assess the influence of group participation on writing productivity (table 7). Only 52% of the India respondents and 36% of the U.S. respondents indicated that group writing is more productive than writing alone. Twenty percent of the India respondents and 35% of the U.S. respondents found that group writing is about as productive as writing alone, and 18% of the India respondents and 16% of the U.S. respondents found that writing in a group is less productive than writing alone.

Of the respondents who did not write alone, 74% of the India group and 47% of the U.S. group worked with the same group when producing written technical communications (table 8). The

Table 7. Influence of Group Participation on Writing Productivity
For India and U.S. Aerospace Engineers and Scientists

Group Participation	India		U.S.	
	%	(n)	%	(n)
A Group Is More Productive Than Writing Alone	52	(37)	36	(54)
A Group Is About As Productive As Writing Alone	20	(14)	35	(52)
A Group Is Less Productive Than Writing Alone	18	(13)	16	(23)
I Only Write Alone	10	(7)	13	(19)

average number of people in the India group was $\bar{X}$ = 4.94 and the average number of people in the

U.S. group was $\bar{X}$ = 3.04. Sixteen percent of the India respondents worked in an average (mean)

number of 4.00 groups, each group containing an average of 3.27 people. Forty percent of the U.S.

respondents worked in an average (mean) number of 2.78 groups, each group containing an average

(mean) of 3.02 people.

Table 8. Production of Written Technical Communications
as a Function of Number of Groups and Group Size For
India and U.S. Aerospace Engineers and Scientists

	India		U.S.	
Groups and Group Size	%	(n)	%	(n)
Worked With Same Group				
Yes	74	(53)	47	(71)
No	16	(11)	40	(60)
I Only Write Alone	10	(7)	13	(19)
Number of People in Group				
Mean	4.94	(53)	3.04	(71)
Median	4.00	(53)	3.00	(71)
Number of Groups				
Mean	4.00	(60)	2.78	(60)
Median	4.00	(60)	3.00	(60)
Number of People in Each Group				
Mean	3.27	(11)	3.02	(60)
Median	3.00	(11)	3.00	(60)

From a prepared list, both groups were asked to indicate the number of times they had

prepared, either alone   as a member of a group, specific technical information products. As

individual authors, the India respondents most frequently **prepared** letters, memoranda,

drawings/specifications, audio/visual materials, and trade/promotional literature (table 9). As part of

a working group, these India aerospace engineers and scientists most frequently **prepared** letters,
trade/promotional literature, memoranda, drawings/specifications,and in-house technical reports. For
these products, the mean number of persons per group ranged from a high of $\overline{X}$ = 3.84 to a low of
$\overline{X}$ = 2.50.

Table 9. Mean (Median) Number of Technical Information Products
Produced in the Past 6 Months by India
Aerospace Engineers and Scientists

Information Product	Alone		In a Group		Average Number of Persons Per Group	
	Mean	Median	Mean	Median	Mean	Median
Abstracts	3.36	(2.00)	3.27	(2.00)	3.23	(3.00)
Journal Articles	1.50	(1.00)	1.89	(1.50)	3.06	(2.00)
Conference/Meeting Papers	2.43	(2.00)	2.74	(2.00)	2.86	(3.00)
Trade/Promotional Literature	3.75	(2.00)	8.00	(8.00)	2.50	(2.50)
Drawings/Specifications	6.27	(3.50)	4.63	(3.50)	2.69	(3.00)
Audio/Visual Materials	4.22	(3.00)	2.63	(2.00)	3.50	(3.00)
Letters	44.88	(20.00)	16.88	(10.00)	2.75	(2.00)
Memoranda	10.94	(4.50)	7.00	(6.00)	2.67	(2.00)
Technical Proposals	1.71	(1.00)	3.17	(2.00)	3.13	(3.00)
Technical Manuals	2.00	(2.00)	2.63	(2.00)	3.38	(2.00)
Computer Program Documentation	1.75	(1.50)	2.59	(2.00)	3.18	(2.00)
In-house Technical Reports	2.35	(2.00)	3.39	(2.00)	3.21	(3.00)
Technical Talks/Presentations	3.20	(2.00)	2.84	(2.00)	3.84	(2.00)

As individual authors, U.S. respondents most frequently **prepared** memoranda, letters,
audio/visual materials, drawings/specifications, and technical talks/presentations (table 10). As a
group, U.S. aerospace engineers and scientists most frequently prepared audio/visual materials, letters,
memoranda, drawings/specifications, and technical talks/presentations. For these products, the mean
number of persons per group ranged from a high of $\overline{X}$ = 4.67 to a low of $\overline{X}$ = 2.00.

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Table 10. Mean (Median) Number of Technical Information Products
Produced in the Past 6 Months by
U.S. Aerospace Engineers and Scientists

Information Product	Alone		In a Group		Average Number of Persons Per Group	
	Mean	Median	Mean	Median	Mean	Median
Abstracts	1.48	(1.00)	1.67	(1.00)	2.64	(2.00)
Journal Articles	1.13	(1.00)	1.54	(1.00)	2.54	(2.00)
Conference/Meeting Papers	1.30	(1.00)	1.66	(1.00)	2.77	(3.00)
Trade/Promotional Literature	1.00	(1.00)	1.00	(1.00)	2.00	(2.00)
Drawings/Specifications	4.19	(2.00)	3.54	(3.00)	2.96	(3.00)
Audio/Visual Materials	6.35	(4.00)	8.64	(3.00)	2.83	(2.00)
Letters	6.39	(5.00)	7.88	(5.00)	2.18	(2.00)
Memoranda	10.72	(6.00)	5.77	(3.50)	2.36	(2.00)
Technical Proposals	2.08	(1.50)	2.38	(2.00)	2.88	(3.00)
Technical Manuals	1.60	(2.00)	2.00	(1.00)	3.00	(3.00)
Computer Program Documentation	2.00	(1.00)	1.78	(1.00)	2.56	(2.00)
In-house Technical Reports	2.04	(1.50)	1.50	(1.00)	2.50	(2.00)
Technical Talks/Presentations	3.61	(2.00)	3.53	(2.00)	3.04	(2.00)
AGARD Technical Reports	1.00	(1.00)	1.33	(1.00)	4.67	(5.00)
U.S. Government Technical Reports	1.27	(1.00)	1.71	(1.00)	2.66	(2.00)

Letters, trade/promotional literature, abstracts, journal articles, and memoranda, and drawings/specifications were the technical information products most frequently used by these India aerospace engineers and scientists (table 11). On the average, they used 42 letters, 22 pieces of trade/promotional literature, 18 abstracts, 17 journal articles, 15 memoranda, and 14 drawings/specifications in a 6-month period. Technical proposals, technical talks/presentations, audio/visual materials, AGARD technical reports, and in-house technical reports were the technical information products least frequently used by these India aerospace engineers and scientists during a 6-month period.

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Memoranda, abstracts, letters, journal articles, and conference/meeting papers were the technical information products most frequently **used** by U.S. aerospace engineers and scientists. On the average, they **used** 22 memoranda, 13 abstracts, 13 letters, 11 journal articles, and 11 conference/meeting papers during a 6-month period. Technical proposals, AGARD technical reports, technical manuals, in-house technical reports, technical talks/presentations, and audio/visual materials were the technical information products least frequently **used** by U.S. aerospace engineers and scientists during a 6-month period.

Table 11. Mean (Median) Number of Technical Information Products
Used in the Past 6 Months by India and
U.S. Aerospace Engineers and Scientists

	India		U.S.	
Information Product	Mean	Median	Mean	Median
Abstracts	18.31	(10.00)	13.10	(6.00)
Journal Articles	17.39	(10.00)	10.81	(6.00)
Conference/Meeting Papers	11.30	(8.00)	10.77	(10.00)
Trade/Promotional Literature	21.68	(10.00)	9.05	(5.00)
Drawings/Specifications	13.71	(6.00)	8.94	(5.00)
Audio/Visual Materials	7.48	(5.00)	8.53	(5.00)
Letters	42.03	(15.00)	12.52	(6.00)
Memoranda	14.80	(10.00)	21.75	(10.00)
Technical Proposals	5.17	(3.00)	3.65	(2.00)
Technical Manuals	9.77	(5.00)	6.47	(5.00)
Computer Program Documentation	9.50	(5.00)	8.46	(5.00)
In-house Technical Reports	8.71	(5.00)	7.10	(5.00)
Technical Talks/Presentations	6.30	(4.50)	9.20	(6.00)
AGARD Technical Reports	7.52	(5.00)	3.68	(3.00)

The types of technical information most frequently **produced** by the India aerospace engineers and scientists included basic scientific and technical information, experimental techniques, in-house technical data, computer programs, and technical specifications (table 12). The types of technical information least frequently **produced** by these India aerospace engineers and scientists included government rules and regulations, economic information, patents and inventions, codes of standards

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and practices, and product and performance characteristics. Basic scientific and technical information, in-house technical data, experimental techniques, computer programs, and technical specifications were the kinds of technical information most frequently **produced** by U.S. aerospace engineers and scientists. Government rules and regulations, codes of standards and practices, economic information, patents and inventions, and product and performance characteristics were the kinds of technical information least frequently **produced** by U.S. aerospace engineers and scientists.

Table 12. Types of Information Produced by India and
U.S. Aerospace Engineers and Scientists
[n = 71; 150]

Information Type	India %	U.S. %
Basic Scientific and Technical Information	78	95
Experimental Techniques	78	75
Codes of Standards and Practices	11	7
Computer Programs	56	54
In-house Technical Data	73	89
Product and Performance Characteristics	42	31
Technical Specifications	48	40
Patents and Inventions	11	30
Government Rules and Regulations	3	4
Economic Information	9	9

The types of technical information most frequently **used** by the India aerospace engineers and scientists included basic scientific and technical information, experimental techniques, in-house technical data, computer programs, and technical specifications (table 13). The types of technical information least frequently **used** by these India aerospace engineers and scientists included patents and inventions, economic information, government rules and regulations, and codes of standards and practices. Basic scientific and technical information, in-house technical data, experimental techniques, computer programs, and technical specifications were the types of technical information most frequently **used** by U.S. aerospace engineers and scientists. Patents and inventions, economic

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information, and codes of standards and practices were the types of technical information least frequently used by the U.S. survey participants.

Table 13. Types of Information Used by India and
U.S. Aerospace Engineers and Scientists
[n = 71; 150]

Information Type	India %	U.S. %
Basic Scientific and Technical Information	87	98
Experimental Techniques	86	89
Codes of Standards and Practices	34	34
Computer Programs	66	88
In-house Technical Data	72	92
Product and Performance Characteristics	47	63
Technical Specifications	65	71
Patents and Inventions	0	15
Government Rules and Regulations	25	51
Economic Information	13	19

Content for an Undergraduate Course in Technical Communications

India and U.S. survey participants were asked their opinions regarding an undergraduate course in technical communications for aerospace majors. Approximately 25% of the India respondents and 76% of the U.S. respondents indicated that they had taken a course(s) in technical communications/writing. (Approximately 75% of the India respondents and 24% of the U.S. respondents indicated they had not taken a course in technical communications/writing.) Approximately 9% of the India participants had taken a course(s) as undergraduates, approximately 14% had taken a course(s) after graduation, and about 3% had taken a course(s) both as undergraduates and after graduation. Approximately 20% of the U.S. respondents had taken a course(s) as undergraduates, approximately 23% had taken a course(s) after graduation, and 33% had taken a course(s) both as undergraduates and after graduation.

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Of the 25% (18 respondents) of the India engineers and scientists who had taken coursework in technical communications/writing, about 21% (15 respondents) of them indicated that doing so had helped them to communicate technical information. Of the 76% (114 respondents) of the U.S. engineers and scientists who had taken a course(s) in technical communications/writing, about 75% (112 respondents) indicated that doing so had helped them to communicate technical information.

India and U.S. participants were asked their opinion regarding the desirability of undergraduate aerospace majors taking a course in technical communications. Approximately 89% of the India respondents and 95% of the U.S. participants indicated that aerospace majors should take such a course. Approximately 49% of the India participants and about 88% of the U.S. participants indicated that the course should be taken for credit (table 14).

The India and U.S. participants were asked if undergraduate aerospace engineering and science majors should take a course in technical communications and, if so, how the course should be offered. About 89% (63 respondents) of the India participants and 95% (126 respondents) of the U.S. participants indicated "yes," that students should take a course in technical communications. About 59% of the India respondents indicated that the course should be taken as part of a "required" course, about 25% thought the course should be taken as part of an "elective" course, none thought it should be taken as a "separate" course, about 4% did not have an opinion, but only 11% of the India respondents indicated that undergraduate aerospace engineering and science students should **not have to take** a course in technical communications/writing. About 80% of the U.S. respondents indicated that the course should be taken as part of a "required" course, about 14% thought the course should be taken as part of

an "elective" course, none thought it should be taken as a "separate" course, about 2% did not have an opinion, but only 5% of the U.S. respondents indicated that undergraduate aerospace engineering and science students should **not have to take** a course in technical communications/writing. A simple majority of both groups indicated that the technical communications/writing instruction should be taken as a separate course (52% of the India respondents and 53% of the U.S. respondents).

Table 14. Opinions Regarding an Undergraduate Course in
Technical Communications for Aerospace Majors

	India		U.S.	
Opinions	%	(n)	%	(n)
Taken for Credit	49	(35)	88	(117)
Not Taken for Credit	34	(24)	2	(3)
Don't Know	6	(4)	5	(6)
Should Not Have to Take Course in Technical Communications	11	(8)	5	(7)

India and U.S. respondents were asked to select from similar lists appropriate principles for inclusion in an undergraduate technical communications course for aerospace engineering and science students. Table 15 shows their responses.

Both India and U.S. respondents indicated that defining the purpose of the communication, organizing information, developing paragraphs, and editing and revising were more important than matters of correctness such as word choice, note-taking and quoting, and writing at the sentence level. Organizing inf.. ..at'r ., defining purpose, and assessing readers' needs are writing process-oriented concerns that are typically stressed in U.S. undergraduate technical writing courses.

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Table 15. Recommended Principles for an Undergraduate
Technical Communications Course for Aerospace Majors

Principles	India		U.S.	
	%	(n)	%	(n)
Organizing Information	90	(64)	95	(143)
Defining the Communication's Purpose	87	(62)	90	(135)
Developing Paragraphs	76	(54)	88	(132)
Assessing Reader's Needs	59	(42)	85	(127)
Choosing Words	55	(39)	87	(130)
Note Taking and Quoting	35	(25)	46	(69)
Editing and Revising	72	(51)	88	(132)
Writing Sentences	52	(37)	71	(106)

The India and U.S. respondents also chose from a list of specific topics appropriate

mechanics to be included in an undergraduate technical communications course for aerospace

majors. Their responses appear in table 16. Both groups of respondents placed references,

symbols, punctuation, and abbreviations in the top four list for inclusion, although not in the

same order of appearance.

Table 16. Recommended Mechanics for an Undergraduate
Technical Communications Course for Aerospace Majors

Mechanics	India		U.S.	
	%	(n)	%	(n)
References	75	(53)	80	(120)
Symbols	58	(41)	66	(99)
Punctuation	51	(36)	72	(108)
Spelling	47	(33)	52	(78)
Abbreviations	56	(40)	53	(80)
Numbers	35	(25)	48	(72)
Capitalization	35	(25)	54	(81)
Acronyms	39	(28)	49	(74)

Given a list of 13 items, the India and U.S. respondents were next asked to select appropriate on-the-job communications to be included in an undergraduate technical communications course. Their responses appear in table 17. Both groups included oral technical presentations, abstracts, use of information sources, conference/meeting papers, technical reports, journal articles among their top choices, although not in the same order of appearance. It is interesting to note that more similarities than differences exist among their choices for the types of written communications that students should learn to produce. These choices may reflect information acquisition and use patterns among aerospace professionals.

Table 17. Recommended On-the-Job Communications To Be Taught in an
Undergraduate Technical Communications Course for Aerospace Majors

On-the-Job Communications	India		U.S.	
	%	(n)	%	(n)
Oral Technical Presentations	78	(55)	91	(136)
Abstracts	76	(54)	88	(132)
Use of Information Sources	59	(42)	73	(110)
Conference/Meeting Papers	66	(47)	68	(102)
Technical Reports	83	(59)	88	(132)
Technical Instructions	56	(40)	61	(92)
Journal Articles	69	(49)	65	(98)
Letters	38	(27)	61	(91)
Technical Specifications	58	(41)	46	(69)
Literature Reviews	62	(44)	49	(74)
Memoranda	28	(20)	56	(84)
Technical Manuals	61	(43)	43	(64)
Newsletter/Paper Articles	32	(23)	12	(18)

In an attempt to validate the findings, the top 10 on-the-job communications were paired with the top five (on average) communications "produced" and "used" by the respondents (table 18). The on-the-job communications recommended by the India respondents do not appear to

closely reflect the types of communications they produce and use, nor do the responses of the U.S. participants appear to reflect the types of communications they produce and use. It is interesting to note that although neither group places technical reports in the top five category of communications produced or used, both groups recommended that technical report writing be taught.

Table 18. Comparison of India and U.S. Responses
Concerning Technical Information Products
Produced, Used, and Recommended

India	U.S.

Produced
    Letters
    Memoranda
    Drawings/Specifications
    Audio/Visual Materials
    Trade/Promotional Literature
	Produced
	    Memoranda
	    Letters
	    Audio/Visual Materials
	    Drawings/Specifications
	    Technical Talks/Presentations

Used
    Letters
    Trade/Promotional Literature
    Abstracts
    Journal Articles
    Memoranda
	Used
	    Memoranda
	    Abstracts
	    Letters
	    Journal Articles
	    Conference/Meeting Papers

Recommended
    Technical Reports
    Oral Technical Presentations
    Abstracts
    Journal Articles
    Conference/Meeting Papers
    Literature Reviews
    Technical Manuals
    Use of Information Sources
    Technical Specifications
    Technical Instructions
	Recommended
	    Oral Technical Presentations
	    Abstracts*
	    Technical Reports*
	    Use of Information Sources
	    Conference/Meeting Papers
	    Journal Articles
	    Technical Instructions
	    Letters
	    Memoranda
	    Literature Reviews

* indicates a tie

Use of Libraries and Technical Information Centers

Almost all of the respondents indicated that their organization has a library or technical information center. Unlike the U.S. respondents (5%), about 56% of the India respondents indicated that the library or technical information center was located in the building where they worked. About 42% of the India and 89% of the U.S. respondents indicated that the library or technical information center was outside the building in which they worked but was located nearby. For 35% of the India group, the library or technical information center was located 1 kilometer or less from where they worked. For about 73% of the U.S. respondents, the library or technical information center was located 1.0 mile or less from where they worked.

Respondents were asked to indicate the number of times they had visited their organization's library or technical information center in the past 6 months (table 19). Overall, the India respondents used their organization's library or technical information center more than their U.S. counterparts did. The average use rate for India respondents was $\bar{X} = 43$ during the past 6 months compared to $\bar{X} = 8.2$ for the U.S. respondents. The median 6-month use rates for the two groups were 27.5 and 4.0, respectively.

Respondents were also asked to rate the importance of their organization's library or technical information center (table 20). Importance was measured on a 5-point scale with 1 = not at all important and 5 = very important. A majority of both groups indicated that their organization's library or technical information center was important to performing their present professional duties. About 90% of the India aerospace engineers and scientists indicated that their organization's library or technical information center was important or very important to

Table 19. Use of the Organization's Library in Past 6 Months
by India and U.S. Aerospace Engineers and Scientists

Visits	India		U.S.	
	%	(n)	%	(n)
0 times	1	(1)	10	(15)
1 - 5 times	4	(2)	44	(60)
6 - 10 times	9	(6)	22	(34)
11 - 25 times	35	(25)	12	(18)
26 - 50 times	28	(20)	5	(7)
51 or more times	21	(15)	1	(1)
Does Not Have A Library	1	(1)	6	(9)
Mean	43.0		8.2	
Median	27.5		4.0	

performing their present professional duties. About 70% of the U.S. aerospace engineers and scientists indicated that their organization's library or technical information center was important or very important to performing their present professional duties. Approximately 1% of the India respondents and approximately 9% of the U.S. respondents indicated that their organization's library or technical information center was very unimportant to performing their present professional duties.

Table 20. Importance of the Organization's Library
to India and U.S. Aerospace Engineers and Scientists

Importance	India		U.S.	
	%	(n)	%	(n)
Very Important	90.1	(64)	70.0	(105)
Neither Important nor Unimportant	7.0	(5)	14.7	(22)
Very Unimportant	1.4	(1)	9.3	(14)
Do Not Have A Library	1.4	(1)	6.0	(9)

From a list of information sources, survey participants were asked to indicate which ones they routinely used in problem solving (table 21). In addition to personal knowledge, upon which they rely greatly, the U.S. aerospace engineers and scientists in this study display information-seeking behavior patterns similar to those of U.S. engineers in general.

Table 21. Information Sources Used by India and
U.S. Aerospace Engineers and Scientists in Problem Solving
[n = 71; 150]

Source	India		U.S.	
	%	(n)	%	(n)
Personal Store Of Technical Information	96	(68)	100	(150)
Spoke With A Co-Worker Or People Inside My Organization	93	(66)	100	(150)
Spoke With A Colleague Outside Of My Organization	75	(53)	93	(139)
Used Literature Resources Found In My Organization's Library	94	(67)	90	(135)
Spoke With A Librarian Or Technical Information Specialist	55	(39)	71	(121)

The information-seeking behavior of the India respondents did not vary greatly from that of their American counterparts. U.S. participants used their personal stores of technical information, co-workers in the organization, literature resources found in the organization's library, colleagues outside the organization, and a librarian or technical information specialist. Their India counterparts used their personal stores of technical information, literature resources found in the organization's library, co-workers in the organization, colleagues outside the organization, and a librarian or technical information specialist.

Use and Importance of Computer and Information Technology

Survey participants were asked if they use computer technology to prepare technical information. Almost all (98%) of the India and U.S. respondents use computer technology to prepare technical information. About 37% of the India respondents and about 62% of the U.S. respondents "always" use computer technology to prepare technical information. A majority of both groups (94% and 97%) indicated that computer technology had increased their ability to communicate technical information. About 70% of the India respondents and 77% of the U.S. respondents stated that computer technology had increased their ability to communicate technical information "a lot".

From a prepared list, survey respondents were asked to indicate which computer software they used to prepare written technical information (table 22). Word processing software was used most frequently by both groups. With the exception of **word processors, outliners and prompters**, and **business graphics**, the U.S. respondents made slightly greater use of computer software for preparing written technical communications than did their India counterparts.

Table 22. Use of Computer Software by India and
U.S. Aerospace Engineers and Scientists to
Prepare Written Technical Communications

Software	India		U.S.	
	%	(n)	%	(n)
Word Processing	99	(70)	95	(142)
Outliners and Prompters	11	(8)	10	(15)
Grammar and Style Checkers	11	(8)	29	(44)
Spelling Checkers	63	(45)	85	(127)
Thesaurus	23	(16)	37	(56)
Business Graphics	14	(10)	11	(17)
Scientific Graphics	85	(60)	90	(135)
Desktop Publishing	34	(24)	50	(75)

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Survey respondents were also given a list of information technologies and asked, "How do you view your use of the following information technologies in communicating technical information?" Their choices included "already use it"; don't use it, but may in the future"; and "don't use it and doubt if I will". (See table 23.)

The India and U.S. aerospace engineers and scientists in this study use a variety of information technologies. The percentages of "I already use it" responses ranged from a high of 85% (FAX or TELEX) to a low of 3% (videoconferencing) for the India respondents. Similarly, the U.S. responses ranged from a high of 91% (FAX or TELEX) to a low of 14% (audio tapes and cassettes).

Table 23. Use, Nonuse, and Potential Use of Information Technologies by India and U.S. Aerospace Engineers and Scientists

Information Technologies	Already Use It		Don't Use It, But May In Future		Don't Use It, And Doubt If Will	
	India %	U.S. %	India %	U.S. %	India %	U.S. %
Audio Tapes and Cassettes	30	14	25	37	45	49
Motion Picture Films	24	18	20	34	56	48
Videotape	53	70	41	26	6	4
Desktop/Electronic Publishing	34	57	53	36	13	7
Computer Cassettes/Cartridge Tapes	63	42	24	34	13	24
Electronic Mail	38	76	58	21	4	3
Electronic Bulletin Boards	6	33	73	51	21	16
FAX or TELEX	85	91	14	7	1	2
Electronic Data Bases	60	54	30	41	10	5
Video Conferencing	3	39	67	49	30	12
Teleconferencing	6	48	29	45	65	7
Micrographics and Microforms	20	24	60	51	20	25
Laser Disk/Video Disk/CD-ROM	11	20	71	66	18	14
Electronic Networks	15	72	75	23	10	5

A list, in descending order, follows of the information technologies most frequently used.

India		U.S.	
FAX or TELEX	85%	FAX or TELEX	91%
Computer Cassettes/		Electronic Mail	76
Cartridge Tapes	63	Electronic Networks	72
Electronic Data Bases	60	Videotape	70
Videotape	53	Desktop Publishing	57
Electronic Mail	38		

A list, in descending order, follows of the information technologies "that are not currently being used but may be used in the future."

India		U.S.	
Electronic Networks	75%	Laser Disk/Video Disk/	
Electronic Bulletin Boards	71	CD-ROM	66%
Laser Disk/Video Disk/		Electronic Bulletin Boards*	51
CD-ROM	71	Micrographics and	
Video Conferencing	67	Microforms*	51
Micrographics and		Video Conferencing	49
Microforms	60	Teleconferencing	45
		Electronic Data Bases	41

*Indicates a tie

Use and Importance of Electronic Networks

Survey participants were asked if they use electronic networks at their workplace in performing their present duties (table 24). Approximately 33% of the India respondents use electronic networks and about 68% either do not use (49%) or do not have access to (19%) electronic networks. About 87% of the U.S. respondents use electronic networks in performing their present duties and about 13% either do not use (9%) or do not have access to (4%) electronic networks.

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Table 24. Use of Electronic Networks by India
and U.S. Aerospace Engineers and Scientists

Percentage of a 40-hour Work Week	India		U.S.	
	%	(n)	%	(n)
0	3	(2)	1	(1)
1 - 25	28	(20)	51	(76)
26 - 50	1	(1)	16	(24)
51 - 75	0	(0)	6	(9)
76 - 99	0	(0)	12	(18)
100	0	(0)	2	(3)
Do Not Use or Have Access to Electronic Networks	68	(48)	13	(19)
Mean	5.3		32.9	
Median	2.0		^0.0	

Respondents were also asked to rate the importance of electronic networks in performing their present duties (table 25). Importance was measured on a 5-point scale with 1 = not at all important and 5 = very important. The U.S. respondents rated electronic networks almost four times as important as their India counterparts did. U.S. and India participants were evenly divided about the importance (neither important nor unimportant) of electronic networks.

Table 25. Importance of Electronic Networks
to India and U.S. Aerospace Engineers and Scientists

Importance	India		U.S.	
	%	(n)	%	(n)
Very Important	14.0	(10)	60.7	(91)
Neither Important nor Unimportant	14.1	(10)	14.0	(21)
Very Unimportant	4.2	(3)	12.7	(19)
Do Not Use or Have Access to Electronic Networks	68.0	(48)	13.0	(19)

electronic networks. Respondents were asked how they accessed electronic networks (table 26): mainframe terminal, personal computers, and workstations. Access via personal computer was most frequently reported.

Table 26. How India and U.S. Aerospace Engineers and Scientists
Access Electronic Networks

Access	India		U.S.	
	%	(n)	%	(n)
Mainframe Terminal	11.3	(8)	10.7	(16)
Personal Computer	21.1	(15)	38.7	(58)
Workstation	0.0	(0)	38.0	(57)
Do Not Use or Have Access to Electronic Networks	67.6	(48)	12.7	(19)

Respondents using them were asked to indicate the purpose(s) for which they used electronic networks (table 27). Although not in the same order, both the India and U.S. respondents indicated that electronic file transfer, electronic mail, remote log in for design/computational tools, and connecting to geographically distant sites represented their greatest use of electronic networks. Also noticeable for both groups is the lack of electronic network use for accessing and searching library catalogs, acquiring (ordering) documents from the library, and searching (bibliographic) data bases.

Survey participants who used electronic networks were asked to identify the groups with whom they exchanged messages or files (table 28). The India respondents did not display a consistent pattern of message and file exchange both within and outside of their organization. Overall, the U.S. group exhibited higher percentages of network use for exchanging messages or files than did their India counterparts. The U.S. respondents displayed a fairly consistent pattern of use as did the India respondents.

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Table 27. Use of Electronic Networks for Specific Purposes by
India and U.S. Aerospace Engineers and Scientists

	India		U.S.	
Purpose	%	(n)	%	(n)
Connect to geographically distant sites	7.0	(5)	57.3	(86)
Electronic mail	23.9	(17)	77.3	(116)
Electronic bulletin boards or conferences	1.4	(1)	32.7	(49)
Electronic file transfer	14.1	(10)	80.0	(120)
Log on to remote computers	14.1	(10)	65.3	(98)
Control remote equipment	4.2	(3)	7.3	(11)
Access/search the library's catalog	14.1	(10)	30.0	(45)
Order documents from the library	7.0	(5)	10.0	(15)
Search electronic (bibliographic) data bases	8.5	(6)	32.0	(48)
Information search and data retrieval	8.5	(6)	34.7	(52)
Prepare scientific and papers with colleagues at geographically distant sites	5.6	(4)	30.0	(45)

Table 28. Use of Electronic Networks by India and U.S.
Aerospace Engineers and Scientists to Exchange Messages or Files

	India		U.S.	
Exchange With --	%	(n)	%	(n)
Members of Own Work Group	8.5	(6)	77.3	(116)
Others In Your Organization But Not In Your Work Group	2.8	(2)	70.7	(106)
Others In Your Organization, Not In Your Work Group, At Geographically Distant Site	8.5	(6)	54.7	(82)
People Outside Your Organization	21.1	(15)	56.0	(84)
Do Not Use or Have Access to Electronic Networks	67.6	(48)	12.7	(19)

Survey participants were asked about the likelihood of their using electronically formatted information that has traditionally appeared as paper products (table 29). With minor exception, both groups are more likely to use online systems (with full text and graphics) for technical

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papers and CD-ROM systems (with full text and graphics) for technical papers than they are to use computer program listings or data tables/mathematical presentations. When asked why they would not use these information products in electronic format, the survey respondents gave the following reasons: (1) 18% of the India and 34% of the U.S. group prefer print (paper) formats; (2) 14% of the India and 35% of the U.S. group cited hardware or software incompatibility; and (3) 37% of the India and 13% of the U.S. group indicated that lack of computer access was the reason for non-use.

Table 29. Attitudes Toward the Use of Information in Specified Formats
by India and U.S. Aerospace Engineers and Scientists

Type of Information	Likely Use of Information in Electronic Format[a]			
	India		U.S.	
	%	(n)	%	(n)
Data Tables/Mathematical Presentations	70.4	(50)	57.4	(86)
Computer Program Listings	74.7	(53)	50.0	(75)
Online System (with Full Text and Graphics) for Technical Papers	80.3	(57)	69.3	(104)
CD-ROM System (with Full Text and Graphics) for Technical Papers	69.0	(49)	56.7	(85)

[a] Likely use was measured on a 1 to 5 point scale with "1" being very unlikely and "5" being very likely. Percentages include combined "4" and "5" responses.

Use of Foreign and Domestically Produced Technical Reports

To better understand the transborder migration of scientific and technical information (STI) via the technical report, survey participants were asked about their use of foreign and domestically produced technical reports (table 30) and the importance of these reports in performing their professional duties (table 31). Both groups make the greatest use of their own technical reports (79% of the India respondents use NAL reports and 96% of the U.S. group use NASA technical reports).

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In addition to their own reports, the India respondents use NASA (96%); AGARD (69%); German DFVLR, DLR, and MBB (58%); and British ARC and RAE (75%) technical reports.

Table 30. Use of Foreign and Domestically Produced Technical Reports by India and U.S. Aerospace Engineers and Scientists

Country/Organization	India		U.S.	
	%	(n)	%	(n)
AGARD	69.0	(49)	85.7	(114)
British ARC and RAE	74.6	(53)	66.9	(89)
ESA	35.2	(25)	8.3	(11)
Indian NAL	78.9	(56)	9.8	(13)
French ONERA	43.7	(31)	50.4	(67)
German DFVLR, DLR, and MBB	57.7	(41)	45.9	(61)
Japanese NAL	18.3	(13)	16.5	(22)
Russian TaAGI	2.8	(2)	16.5	(22)
Dutch NLR	31.0	(22)	25.6	(34)
U.S. NASA	95.8	(68)	97.0	(129)

In addition to their own reports, the U.S. group uses AGARD (86%) and British ARC and RAE (67%) technical reports. Neither group makes great use of Japanese NAL, Dutch NLR, ESA, or Russian TsAGI technical reports. Survey participants were also asked about their access to these technical reports series. Overall, the U.S. group appears to have better access to foreign technical reports than do their India counterparts. Both groups have about equal access to NASA technical reports.

Technical report importance was measured on a 5-point scale with 1 = very unimportant and 5 = very important. Both groups were asked to rate the importance of selected foreign and domestic technical reports in performing their present professional duties. The average (mean) importance ratings are shown in table 31. The India respondents rated the importance of U.S. NASA reports ($\bar{X}$ = 4.47) followed by AGARD ($\bar{X}$ = 4.30), and British ARC and RAE reports

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($\bar{X}$ = 4.16). The U.S. group rated NASA reports most important ($\bar{X}$ = 4.37) followed by AGARD

($\bar{X}$ = 3.65) and British ARC and RAE reports ($\bar{X}$ = 3.22).

Table 31. Importance of Foreign and Domestically Produced Technical Reports
to India and U.S. Aerospace Engineers and Scientists

Country/Organization	India		U.S.	
	Rating[a] $\bar{X}$	(n)	Rating[a] $\bar{X}$	(n)
AGARD	4.30	(69)	3.65	(133)
British ARC and RAE	4.16	(69)	3.22	(127)
ESA	3.77	(62)	1.52	(116)
Indian NAL	3.97	(70)	1.51	(116)
French ONERA	3.25	(63)	2.48	(123)
German DFVLR, DLR, and MBB	3.50	(62)	2.40	(119)
Japanese NAL	2.63	(35)	1.75	(113)
Russian TaAGI	2.15	(20)	1.81	(109)
Dutch NLR	3.03	(34)	1.95	(118)
U.S. NASA	4.47	(71)	4.37	(133)

[a] A 1 to 5 point scale was used to measure importance with "1" being
the lowest possible importance and "5" being the highest possible
importance. Hence, the higher the average (mean) the greater the
importance of the report series.

DISCUSSION

Given the limited purposes of this exploratory study, the overall response rates, and the

research designs, no claims are made regarding the extent to which the attributes of the

respondents in the studies accurately reflect the attributes of the populations being studied. A

much more rigorous research design and methodology would be needed before any claims could

be made. Nevertheless, the findings of the studies do permit the formulation of the following

general statements regarding the technical communications practices of the aerospace engineers

and scientists who participated in the two studies:

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1. The ability to communicate technical information effectively is important to India and U.S. aerospace scientists and engineers.

2. As the India and U.S. aerospace engineers and scientists in these studies have advanced professionally, the amount of time they spend producing and working with technical communications has increased for three-quarters (75%) of the India respondents and slightly more than two-thirds (69%) of the U.S. respondents.

3. The India and U.S. aerospace engineers and scientists in these studies write more frequently in small groups than alone. They find collaborative writing more productive than individual writing. Both groups of respondents frequently produce about the same types of materials whether they write as members of a group or as individuals.

4. The India and U.S. aerospace engineers and scientists in these studies make use of personal knowledge, discussions with colleagues within their organization, and literature resources found within the organization's library for solving technical problems. The India group, much more than the U.S. group, places greater reliance on librarians or technical information specialists for ascertaining information used in problem solving.

5. Approximately 25% of the India and 76% of the U.S. aerospace engineers and scientists in these studies had taken a course in technical communications. About 21% of the India and about 75% of the U.S. respondents indicated that such a course had helped them communicate technical information.

6. Although the percentages vary for each item, there was considerable agreement among the India and U.S. aerospace engineers and scientists in these studies regarding the on-the-job communications to be included in an undergraduate technical communications course for aerospace and science students. There was also considerable agreement on the appropriate principles and mechanics that should be included in such a course.

7. Although important to both India and U.S. aerospace engineers and scientists, libraries and technical information centers were used much more by the India respondents. More India aerospace engineers and scientists had a library or technical information center located in their building than did their U.S. counterparts.

8. Both groups made considerable use of computer technology to prepare technical information and about three-quarters of both groups indicated that computer technology had increased their ability to communicate technical information.

9. With the exception of word processors, outliners and prompters, and business graphics, U.S. aerospace engineers and scientists made somewhat greater use of computer software than did their India counterparts.

10. There were notable similarities between the two groups in terms of the information technologies presently being used and those that might be used in the future.

11. U.S. aerospace engineers and scientists made greater use of electronic networks than did their India counterparts and rated the use of electronic networks almost four times as important as their India counterparts rated electronic network use. Both groups reported similar use of electronic networks. U.S. aerospace engineers and scientists made greater use of electronic networks to access/search the library's catalog, read electronic (bibliographic) databases, and retrieve information than did their India counterparts.

12. U.S. and India respondents make the greatest use of NASA technical reports and rank them highest in terms of importance in performing their professional duties. Both groups make extensive use of (and consider important) AGARD and British ARC and RAE technical reports.

13. Apart from English, both groups reported limited fluency (reading and speaking) in French, German, Japanese, and Russian.

CONCLUDING REMARKS

Despite the limitations of this investigation, these findings contribute to our knowledge and understanding of the technical communications practices among aerospace engineers and scientists at the national and international levels. The findings reinforce some of the conventional wisdom regarding the nature and importance of technical communications and the amount of time that engineers and scientists devote to communicating technical information and raise questions about their use of information sources and resources, particularly in light of current technologies. The results of this study should prove useful to R&D managers, library and information science professionals, curriculum developers, and technical communicators.

ACKNOWLEDGMENTS

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[8]   Pinelli, T. E.; M. Glassman; W. E. Oliu; and R. O. Barclay. *Technical Communication in Aeronautics: Results of an Exploratory Study.* Part 1. Washington, DC: National Aeronautics and Space Administration. NASA TM-101534, February 1989. (Available from NTIS, Springfield, VA; 89N26772.)

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APPENDIX A

AEROSPACE KNOWLEDGE
DIFFUSION RESEARCH PROJECT

Fact Sheet

A research study is investigating the production, transfer, and use of scientific and technical information (STI) in aerospace, a community which is becoming more interdisciplinary in nature and more international in scope. Sponsored by the National Aeronautics and Space Administration, the Aerospace Knowledge Diffusion Research Project is being conducted by the Indiana University Center for Survey Research, the NASA Langley Research Center, RPI, and selected universities in the U.S. and abroad.

This 4-phase project will provide descriptive and analytical data regarding the flow of STI at the individual, organizational, national, and international levels. It will examine both the channels used to communicate STI and the social system of the aerospace knowledge diffusion process. The results of the project should provide useful information to R&D managers, information managers, and others concerned with improving access to and utilization of STI. Phases 1 and 4 investigate the information-seeking habits and practices of U.S. and non-U.S. engineers, scientists, and engineering and science students. Phase 2 examines the industry-government interface and places particular emphasis on the role of the information intermediary in the knowledge diffusion process. Phase 3 explores the academic-government interface and places particular emphasis on the faculty-student-information intermediary relationship.

Empirically, little is known about the production, transfer, and use of aerospace STI in general and about the information-seeking behavior of engineers, scientists, and engineering and science students. Less is known about the effectiveness of information intermediaries and the roles they play in knowledge diffusion although their roles are generally assumed to be significant ones. However, a strong methodological base for measuring or assessing their effectiveness is lacking.

The ability of aerospace engineers and scientists to identify, acquire, and utilize STI is of paramount importance to the efficiency of the R&D process. An understanding of the process by which aerospace STI is communicated through certain channels over time among members of the social system would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of engineers and scientists.

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APPENDIX B
NASA/DoD AEROSPACE KNOWLEDGE DIFFUSION
RESEARCH PROJECT PUBLICATIONS

REPORTS

<u>Report No.</u>

1
PART 1
Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communications in Aerospace: Results of Phase 1 Pilot Study.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101534. February 1989. 106 p. (Available from NTIS 89N26772.)

1
PART 2
Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communications in Aerospace: Results of a Phase 1 Pilot Study.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101534. February 1989. 83 p. (Available from NTIS 89N26773.)

2
Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communication in Aerospace: Results of Phase 1 Pilot Study -- An Analysis of Managers' and Nonmanagers' Responses.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101625. August 1989. 58 p. (Available from NTIS 90N11647.)

3
Pinelli, Thomas E.; Myron Glassman; Walter E. Oliu; and Rebecca O. Barclay. **Technical Communication in Aerospace: Results of Phase 1 Pilot Study -- An Analysis of Profit Managers' and Nonprofit Managers' Responses.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101626. October 1989. 71 p. (Available from NTIS 90N15848.)

4
Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 1 Respondents.** Washington, DC: National Aeronautics and Space Administration. NASA TM-102772. January 1991. 8 p. (Available from NTIS 91N17835.)

5
Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 1 Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-102773. January 1991. 53 p. (Available from NTIS 91N20988.)

6
Pinelli, Thomas E. **The Relationship Between the Use of U.S. Government Technical Reports by U.S. Aerospace Engineers and Scientists and Selected Institutional and Sociometric Variables.** Washington, DC: National Aeronautics and Space Administration. NASA TM-102774. January 1991. 350 p. (Available from NTIS 91N18898.)

7
Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 2 Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104063. March 1991. 42 p. (Available from NTIS 91N22931.)

8   Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 3 Faculty and Student Respondents.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104085. June 1991. 8 p. (Available from NTIS 91N24943.)

9   Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 3 Faculty and Student Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104086. June 1991. 42 p. (Available from NTIS 91N25950.)

10   Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Summary Report to Phase 3 Academic Library Respondents Including Frequency Distributions.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104095. August 1991. 42 p. (Available from NTIS 91N33013.)

11   Pinelli, Thomas E.; Madeline Henderson; Ann P. Bishop; and Philip Doty. **Chronology of Selected Literature, Reports, Policy Instruments, and Significant Events Affecting Federal Scientific and Technical Information (STI) in the United States.** Washington, DC: National Aeronautics and Space Administration. NASA TM-101662. January 1992. 130 p. (Available from NTIS 92N17001.)

12   Glassman, Nanci A. and Thomas E. Pinelli. **An Initial Investigation Into the Production and Use of Scientific and Technical Information (STI) at Five NASA Centers: Results of a Telephone Survey.** Washington, DC: National Aeronautics and Space Administration. NASA TM-104173. June 1992. 80 p. (Available from NTIS 92N27170.)

13   Pinelli, Thomas E. and Nanci A. Glassman. **Source Selection and Information Use by U.S. Aerospace Engineers and Scientists: Results of a Telephone Survey.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107658. September 1992. 27 p. (Available from NTIS 92N33299.)

14   Pinelli, Thomas E.; John M. Kennedy; and Terry F. White. **Engineering Work and Information Use in Aerospace: Results of a Telephone Survey.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107673. October 1992. 25 p. (Available from NTIS 92N34233.)

15   Pinelli, Thomas E.; Nanci A. Glassman; Linda O. Affelder; Rebecca O. Barclay; and John M. Kennedy. **Technical Uncertainty and Project Complexity as Correlates of Information Use by U.S. Aerospace Engineers and Scientists: Results of an Explanatory Investigation.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107693. August 1993. 68 p. (NTIS pending.)

16   Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **A Comparison of the Technical Communications Practices of Russian and U.S. Aerospace Engineers and Scientists.** Washington, DC: National Aeronautics and Space Administration. NASA TM-107714. January 1993. 56 p. (Available from NTIS 93N18160.)

PAPERS

Paper No.

1   Pinelli, Thomas E.; Myron Glassman; Rebecca O. Barclay; and Walter E. Oliu. **The Value of Scientific and Technical Information (STI), Its Relationship to Research and Development (R&D), and Its Use by U.S. Aerospace Engineers and Scientists.** Paper presented at the European Forum "External Information: A Decision Tool" January 19, 1990, Strasbourg, France. (Available from AIAA 90A21931.)

2   Blados, Walter R.; Thomas E. Pinelli; John M. Kennedy; and Rebecca O. Barclay. **External Information Sources and Aerospace R&D: The Use and Importance of Technical Reports by U.S. Aerospace Engineers and Scientists.** Paper prepared for the 68th AGARD National Delegates Board Meeting, 29 March 1990, Toulouse, France. (Available from NTIS 90N30132.)

3   Kennedy, John M. and Thomas E. Pinelli. **The Impact of a Sponsor Letter on Mail Survey Response Rates.** Paper presented at the Annual Meeting of the American Association for Public Opinion Research, May 1990, Lancaster, PA. (Available from NTIS 92N28112.)

4   Pinelli, Thomas E.; Rebecca O. Barclay; John M. Kennedy; and Myron Glassman. **Technical Communications in Aerospace: An Analysis of the Practices Reported by U.S. and European Aerospace Engineers and Scientists.** Paper presented at the International Professional Communication Conference (IPCC), Post House Hotel, Guilford, England, 14 September 1990. (Available from NTIS 91N14079; and AIAA 91A19799.)

5   Pinelli, Thomas E. and John M. Kennedy. **Aerospace Librarians and Technical Information Specialists as Information Intermediaries: A Report of Phase 2 Activities of the NASA/DoD Aerospace Knowledge Diffusion Research Project.** Paper presented at the Special Libraries Association, Aerospace Division - 81st Annual Conference, Pittsburgh, PA, June 13, 1990. (Available from AIAA 91A19804.)

6   Pinelli, Thomas E. and John M. Kennedy. **Aerospace Knowledge Diffusion in the Academic Community: A Report of Phase 3 Activities of the NASA/DoD Aerospace Knowledge Diffusion Research Project.** Paper presented at the 1990 Annual Conference of the American Society for Engineering Education - Engineering Libraries Division, Toronto, Canada, June 27, 1990. (Available from AIAA 91A19803.)

7   Pinelli, Thomas E. and John M. Kennedy. **The NASA/DoD Aerospace Knowledge Diffusion Research Project: The DoD Perspective.** Paper presented at the Defense Technical Information Center (DTIC) 1990 Annual Users Training Conference, Alexandria, VA, November 1, 1990. (Available from AIAA 91N28033.)

8   Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **The Role of the Information Intermediary in the Diffusion of Aerospace Knowledge.** Reprinted from *Science and Technology Libraries,* Volume 11, No. 2 (Winter), 1990: 59-76.   (Available from NTIS 92N28113.)

9   Eveland, J.D. and Thomas E. Pinelli. **Information Intermediaries and the Transfer of Aerospace Scientific and Technical Information (STI): A Report From the Field.** Paper commissioned for presentation at the 1991 NASA STI Annual Conference held at the NASA Marshall Space Flight Center, Huntsville, AL, April 9, 1991.   (Available from NTIS 91N21959.)

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1 1   Pinelli, Thomas E. and John M. Kennedy. **The Voice of the User -- How U.S. Aerospace Engineers and Scientists View DoD Technical Reports.** Paper presented at the 1991 Defense Technical Information Center's (DTIC) Managers Planning Conference, Solomon's Island Holiday Inn, MD, May 1, 1991. (Available from AIAA 91A41123.)

1 2   Pinelli, Thomas E.; John M. Kennedy; and Rebecca O. Barclay. **The Diffusion of Federally Funded Aerospace Research and Development (R&D) and the Information-Seeking Behavior of U.S. Aerospace Engineers and Scientists.** Paper presented at the Special Libraries Association (SLA) 82nd Annual Conference, San Antonio, TX, June 11, 1991. (Available from AIAA 92A29652.)

1 3   Pinelli, Thomas E. **The Information-Seeking Habits and Practices of Engineers.** Reprinted from *Science & Technology Libraries,* Volume 11, No. 3, (Spring) 1991: 5-25.   (Available from NTIS 92N28114.)

1 4   Barclay, Rebecca O.; Thomas E. Pinelli; David Elazar; and John M. Kennedy. **An Analysis of the Technical Communications Practices Reported by Israeli and U.S. Aerospace Engineers and Scientists.** Paper presented at the International Professional Communication Conference (IPCC), The Sheraton World Resort, Orlando, FL, November 1, 1991. (Available from NTIS 92N28183.)

1 5   Barclay, Rebecca O.; Thomas E. Pinelli; Michael L. Keene; John M. Kennedy; and Myron Glassman. **Technical Communications in the International Workplace: Some Implications for Curriculum Development.** Reprinted from *Technical Communication,* Volume 38, No. 3 (Third Quarter, August 1991): 324-335.   (Available from NTIS 92N28116.)

1 6   Pinelli, Thomas E.; John M. Kennedy; Rebecca O. Barclay; and Terry F. White. **Aerospace Knowledge Diffusion Research.** Reprinted from *World Aerospace Technology '91: The International Review of Aerospace Design and Development,* Volume 1 (1991): 31-34. (Available from NTIS 92N28220.)

17   Pinelli, Thomas E.; Rebecca O. Barclay; John M. Kennedy; Nanci Glassman; and
        Loren Demerath. **The Relationship Between Seven Variables and the Use
        of U.S. Government Technical Reports by U.S. Aerospace Engineers and
        Scientists.** Paper presented at the 54th Annual Meeting of the American Society
        for Information Science (ASIS), The Washington Hilton & Towers, Washington, DC,
        October 30, 1991. (Available from NTIS 92N28115.)

18   Hernon, Peter and Thomas E. Pinelli. **Scientific and Technical Information
        (STI) Policy and the Competitive Position of the U.S. Aerospace
        Industry.** Paper presented at the 30th Aerospace Meeting of the American
        Institute of Aeronautics and Astronautics (AIAA), Bally's Grand Hotel, Reno, NV,
        January 1992. (Available from AIAA 92A28233.)

19   Pinelli, Thomas E.; John M. Kennedy; Rebecca O. Barclay; and Ann P. Bishop.
        **Computer and Information Technology and Aerospace Knowledge
        Diffusion.** Paper presented at the Annual Meeting of the American Association for
        the Advancement of Science (AAAS), The Hyatt Regency Hotel, Chicago, IL,
        February 8, 1992. (Available from NTIS 92N28211.)

20   Holland, Maurita P.; Thomas E. Pinelli; Rebecca O. Barclay; and John M. Kennedy.
        **Engineers As Information Processors: A Survey of U.S. Aerospace
        Engineering Faculty and Students.** Reprinted from the *European Journal of
        Engineering Education*, Volume 16, No. 4 (1991): 317-336. (Available from
        NTIS 92N28155.)

21   Pinelli, Thomas E.; Rebecca O. Barclay; Maurita P. Holland; Michael L. Keene;
        and John M. Kennedy. **Technological Innovation and Technical
        Communications: Their Place in Aerospace Engineering Curricula.
        A Survey of European, Japanese, and U.S. Aerospace Engineers and
        Scientists.** Reprinted from the *European Journal of Engineering Education*,
        Volume 16, No. 4 (1991): 337-351. (Available from NTIS 92N28184.)

22   Pinelli, Thomas E. **Establishing a Research Agenda for Scientific and
        Technical Information (STI): Focus on the User.** Paper presented at the
        "Research Agenda in Information Science" workshop sponsored by the Advisory
        Group for Aerospace Research and Development (AGARD), April 7-9 1992, Lisbon,
        Portugal. (Available from NTIS 92N28117.)

23   Pinelli, Thomas E.; Rebecca O. Barclay; Ann P. Bishop; and John M. Kennedy.
        **Information Technology and Aerospace Knowledge Diffusion:
        Exploring the Intermediary-End User Interface in a Policy
        Framework.** Reprinted from *Electronic Networking: Research, Applications
        and Policy.* 2:2 (Summer 1992): 31-49. (Available from NTIS 93N12007.)

24   Brinberg, Herbert R. and Thomas E. Pinelli. **A General Approach to
        Measuring the Value of Aerospace Information Products and Services.**
        Paper presented at the 31st Aerospace Sciences Meeting and Exhibits of the
        American Institute of Aeronautics and Astronautics (AIAA), Bally's Grand Hotel,
        Reno, Nevada, January 11-13, 1993. (Available from AIAA 93A17511.)

25   Kohl, John R.; Rebecca O. Barclay; Thomas E. Pinelli; Michael L. Keene; and
      John M. Kennedy. **The Impact of Language and Culture on Technical
      Communication in Japan.** Reprinted from *Technical Communication*, Volume
      40, No. 1 (First Quarter, February 1993): 62-73. (Available from NTIS
      93N17592.)

26   Pinelli, Thomas E.; Rebecca O. Barclay; and John M. Kennedy. **The Relationship
      Between Technology Policy and Scientific and Technical Information
      Within the U.S. and Japanese Aerospace Industries.** Paper presented at
      the Third Annual JICST/NTIS Conference on *How to Locate and Acquire Japanese
      Scientific and Technical Information*, The Nikko Hotel, San Francisco, California,
      March 18, 1993. (Available from NTIS 93N20111).

27   Pinelli, Thomas E.; Rebecca O. Barclay; Stan Hannah; Barbara Lawrence; and
      John M. Kennedy. **Knowledge Diffusion and U.S. Government Technology
      Policy: Issues and Opportunities for Sci/Tech Librarians.** Reprinted
      from *Science and Technology Libraries*, Volume 13, Number 1 (1992): 33-55.
      (Available from NTIS 93N20110.)

28   ⌐inelli, Thomas E.; Rebecca O. Barclay; Michael L. Keene; Madelyn Flammia; and
      John M. Kennedy. **The Technical Communication Practices of Russian and
      U. S. Aerospace Engineers and Scientists.** Reprinted from *IEEE Transactions
      on Professional Communication*, Volume 36, No. 2 (June 1993): 95-104 (NTIS
      pending.)

29   Pinelli, Thomas E.; Rebecca O. Barclay; and John M. Kennedy. **The U.S.
      Government Technical Report and the Transfer of Federally Funded
      Aerospace R&D.** Reprinted from *Government Publications Review*, Volume 20,
      No. 3 (July/August 1993): 393-411. (NTIS pending.)

30   Pinelli, Thomas E.; Ann P. Bishop; Rebecca O. Barclay; and John M. Kennedy. **The
      Electronic Transfer of Information and Aerospace Knowledge
      Diffusion.** Reprinted from the *International Forum on Information and
      Documentation*, Volume 17, No. 4 (October 1992): 8-16. (NTIS pending.)

31   Pinelli, Thomas E.; Ann P. Bishop; Rebecca O. Barclay; and John M. Kennedy. **The
      Information - Seeking Behavior of Engineers.** Reprinted from the
      Encyclopedia of Library and Information Science, Volume 52, Supplement 15
      (1993): 167-201. (NTIS pending.)

APPENDIX C
SURVEY INSTRUMENT

Technical Communications in Aerospace: An International Perspective

An Exploratory Study Conducted in India

Phase 4 of the Aerospace Knowledge Diffusion Research Project

---

1. In your work, how important is it for you to communicate (e.g., producing written materials or oral discussions) technical information effectively? (Circle number)

   Very Unimportant   1   2   3   4   5   Very Important

2. In the past 6 months, about how many hours did you spend each week communicating technical information?

   (output) _____ hours per week writing

   _____ hours per week communicating orally

3. Compared to 5 years ago, how has the amount of time you have spent **communicating** technical information changed? (Circle number)

   1. Increased

   2. Stayed the same

   3. Decreased

4. In the past 6 months, about how many hours did you spend each week working with technical information received from others?

   (input) _____ hours per week working with written information

   _____ hours per week receiving information orally

5. As you have advanced professionally, how has the amount of time you have spent working with technical information **received from others** changed? (Circle number)

   1. Increased

   2. Stayed the same

   3. Decreased

6. What percentage of your written technical communications involve:

Writing alone	__% ———►(If 100% alone, go to Question 9.)
Writing with one other person	__%
Writing with a group of 2 to 5 persons	__%
Writing with a group of more than 5 persons	__%
	100%

7. In general, do you find writing as part of a group more or less productive (i.e., producing more written products or producing better written products) than writing alone? (Circle number)

1. A group is less productive than writing alone

2. A group is about as productive as writing alone

3. A groups is more productive than writing alone

4. Difficult to judge; no experience preparing technical information

8. In the past 6 months, did you work with the same group of people when producing written technical communications? (Circle number)

1. Yes ——►About how many people were in the group: _____number of people

2. No ——►With about how many groups did you work: _____number of groups
   ↓

   About how many people were in each group: _____number of people

9. Approximately how many times in the past 6 months did you write or prepare the following alone or in a group? (If in a group, how many people were in each group?)

Times in Past 6 Months Produced

	Alone	In a Group	
a. Abstracts	___Times	___Times	___Average No. of People
b. Journal articles	___	___	___
c. Conference/Meeting papers	___	___	___
d. Trade/Promotional literature	___	___	___
e. Drawings/Specifications	___	___	___
f. Audio/Visual materials	___	___	___
g. Letters	___	___	___
h. Memoranda	___	___	___
i. Technical proposals	___	___	___
j. Technical manuals	___	___	___
k. Computer program documentation	___	___	___
l. AGARD technical reports	___	___	___
m. In-house technical reports	___	___	___
n. Technical talks/Presentations	___	___	___

10. Approximately how many times in the past 6 months did you use the following?

    a. Abstracts   __Times used in 6 months

    b. Journal articles   —

    c. Conference/Meeting papers   —

    d. Trade/Promotional literature   —

    e. Drawings/Specifications   —

    f. Audio/Visual materials   —

    g. Letters   —

    h. Memoranda   —

    i. Technical proposals   —

    j. Technical manuals   —

    k. Computer program documentation   —

    l. AGARD technical reports   —

    m. In-house technical reports   —

    n. Technical talks/Presentations   —

11. What types of technical information do you *USE* in your present job? (Circle appropriate numbers)

	Yes	No
Basic scientific and technical information	1	2
Experimental techniques	1	2
Codes of standards and practices	1	2
Computer programs	1	2
Government rules and regulations	1	2
In-house technical data	1	2
Product and performance characteristics	1	2
Economic information	1	2
Technical specifications	1	2
Patents	1	2

12. What types of technical information do you *PRODUCE* (or expect to produce) in your present job? (Circle appropriate number)

	Yes	No
Basic scientific and technical information	1	2
Experimental techniques	1	2
Codes of standards and practices	1	2
Computer programs	1	2
Government rules and regulations	1	2
In-house technical data	1	2
Product and performance characteristics	1	2
Economic information	1	2
Technical specifications	1	2
Patents	1	2

15. Have you ever taken a course in technical communications/writing? (Circle the appropriate number)

1. Yes, as an undergraduate
2. Yes, after graduation
3. Yes, both
4. Presently taking
5. No

16. How much did this course help you to communicate technical information? (Circle the appropriate number)

1. A lot
2. A little
3. Not at all

17. Do you think that undergraduate aerospace engineering and science students should have training or course work in technical communications (e.g., technical writing/oral presentations)? (Circle the appropriate number)

1. Yes

2. No

3. Don't know

Go to Question 21.

If you answered "yes" to Question 17, please answer Questions 18, 19, and 20.

18. Do you think a technical communications course for undergraduate aerospace engineering and science students should be: (Circle the appropriate number)

1. Taken for academic credit

2. Not taken for academic credit

3. Don't know

19. Do you think the technical communications course should be: (Circle the appropriate number)

    1. Taken as part of a required course

    2. Taken as part of an elective course

    3. Don't know

20. Do you think the technical communications course should be: (Circle the appropriate number)

    1. Taken as part of an engineering course (e.g., Engineering 201)

    2. Taken as a separate course (e.g., Technical Writing 101)

    3. Taken as part of another course (i.e., neither Engineering or English)

    4. Don't know

21. Which of the following **principles** should be included in an undergraduate technical communications course for aerospace engineers and scientists? (Circle the appropriate numbers)

	Yes	No
Defining the purpose of the communication	1	2
Assessing the needs of the reader	1	2
Organizing information	1	2
Developing paragraphs (introductions, transitions, and conclusions)	1	2
Writing sentences	1	2
Notetaking and quoting	1	2
Editing and revising	1	2
Choosing words (avoiding wordiness, jargon, slang, sexist terms)	1	2
Other (specify) _____		

22. Which of the following **mechanics** should be included in an undergraduate technical communications course for aerospace engineers and scientists? (Circle the appropriate numbers)

	Yes	No
Abbreviations	1	2
Acronyms	1	2
Capitalization	1	2
Numbers	1	2
Punctuation	1	2
References	1	2
Spelling	1	2
Symbols	1	2
Other (specify) _____		

23. Which of the following on-the-job skills should be included in an undergraduate technical communications course for aerospace engineers and scientists? (Circle the appropriate numbers)

	Yes	No
Abstracts	1	2
Letters	1	2
Memoranda	1	2
Technical instructions	1	2
Journal articles	1	2
Conference/Meeting papers	1	2
Literature reviews	1	2
Technical manuals	1	2
Newsletter/newspaper articles	1	2
Oral (technical) presentations	1	2
Technical specifications	1	2
Technical reports	1	2
Use of information sources	1	2

Other (specify) _____

24. Do you use computer technology to prepare technical information? (Circle the appropriate number)

1. Always
2. Usually
3. Sometimes
4. Never ⊢————————▶ Go to Question 27.

If you answered "never" to Question 24, please skip to Question 27, otherwise, please answer Question 25.

25. How much has computer technology increased your ability to communicate technical information? (Circle the appropriate number)

1. Yes, a lot
2. Yes, a little
3. No, not really
4. No, not at all

26. Do you use any of the following software to prepare written technical information? (Circle the appropriate numbers)

	Yes	No
Word processing	1	2
Outliners and prompters	1	2
Grammar and style checkers	1	2
Spelling checkers	1	2
Thesaurus	1	2
Business graphics	1	2
Scientific graphics	1	2
Desktop publishing	1	2

27. How do you view your use of the following electronic/information technologies in communicating technical information? (Circle the appropriate number)

Information Technologies	I already use it	I don't use it, but may in the future	I don't use it and doubt if I will
Audio tapes and cassettes	1	2	3
Motion picture film	1	2	3
Video tape	1	2	3
Desk top/electronic publishing	1	2	3
Computer cassette/cartridge tapes	1	2	3
Electronic Mail	1	2	3
Electronic bulletin boards	1	2	3
FAX or TELEX	1	2	3
Electronic data bases	1	2	3
Video conferencing	1	2	3
Computer conferencing	1	2	3
Micrographics & microforms	1	2	3
Laser disc/video disc/CD-ROM	1	2	3
Electronic networks	1	2	3

28. At your work place, do you use electronic networks in performing your present duties?

1. Yes

2. No
⟶ Go to question 34.
3. No because I do not have access to electronic networks

If you answered "yes" to Question 28, please answer questions 29, 30, 31, 32, and 33.

29. At your work place, how do you access electronic networks?

1. By using a mainframe terminal

2. By using a personal computer

3. By using a workstation

30. How important is the use of electronic networks in performing your present duties?

Very Unimportant   1   2   3   4   5   Very Important

31. In the past week, how many hours did you use electronic (computer) networks?

_____Hours in past week

32. Do you use electronic networks for the following purposes?

	Yes	No
1. To connect to geographically distant sites	1	2
2. For electronic mail	1	2
3. For electronic bulletin boards or conferences	1	2
4. For electronic file transfer	1	2
5. To log into remote computers for such things as computational analysis or to use design tools	1	2
6. To control remote equipment such as laboratory instruments or machine tools	1	2
7. To access/search the library's catalogue	1	2
8. To order documents from the library	1	2
9. To search electronic (bibliographic) data bases (e.g., Dialog)	1	2
10. For information search and data retrieval	1	2
11. To prepare scientific and technical papers with colleagues at geographically distant sites	1	2

33. Do you use electronic (computer) networks to communicate with:

	Yes	No
1. Members of your work group	1	2
2. Other people in your organization (at the **SAME** geographic site) who are not in your work group	1	2
3. Other people in your organization (at a geographically **DIFFERENT** site) who are **NOT** in your work group	1	2
4. People outside of your organization	1	2

34. How likely would you be to use the following information if it was available in electronic format?

	Very Unlikely				Very Likely
1. Data tables/mathematical presentations	1	2	3	4	5
2. Computer program listings	1	2	3	4	5
3. Online system (with full text and graphics) for technical papers	1	2	3	4	5
4. CD-ROM system (with full text and graphics) for technical reports	1	2	3	4	5

35. Which of the following best explains why you would not be using these materials in electronic format?

1. No/limited computer access

2. Hardware/software incompatibility

3. Prefer printed format

4. Other (specify) _____

51

36. Does your organization have a library/technical information center? (Circle the appropriate number)

    1. Yes, in my building

    2. Yes, but not in my building ⟶ ___Km

    3. No ⟶ Go to Question 39.

    If you answered "yes" to Question 36, please answer Questions 37 and 38.

37. In the past six months, about how often did you use your organization's library/technical information center?

    _____Number of times in past 6 months

38. In terms of performing your present professional duties, how important is your organization's library/technical information center? (Circle the appropriate number)

    Not at all important   1   2   3   4   5   Very important

39. When faced with solving a technical problem, which of the following sources do you usually consult?

    ↑

    Please sequence these items (e.g., #1, #2, #3, #4, #5) and put an X beside the steps you did not use.

    Sequence

    _____Used my personal store of technical information, including sources I keep in my office

    _____Spoke with co-workers or people inside by organization

    _____Spoke with colleagues outside my organization

    _____Spoke with a librarian or technical information specialist

    _____Used literature resources (e.g., conference papers, journals, technical reports) found in my organization's library)

    (If you used none of the above steps, check here_____.)

40. Do you use the following technical reports in performing your present professional duties? (Circle numbers)

		Yes	No	Don't Have Access
1	AGARD reports	1	2	9
2	British ARC and RAE reports	1	2	9
3	ESA reports	1	2	9
4	Indian NAL	1	2	9
5	French ONERA reports	1	2	9
6	German DFVLR, DLR, and MBB reports . .	1	2	9
7	Japanese NAL reports	1	2	9
8	Russian TsAGI reports	1	2	9
9	Dutch NLR reports	1	2	9
10	U.S. NASA reports	1	2	9

41. How important are these reports in performing your present professional duties? (Circle numbers)

		Very Unimportant				Very Important	Don't Have Access
1	AGARD reports	1	2	3	4	5	9
2	British ARC and RAE reports	1	2	3	4	5	9
3	ESA reports	1	2	3	4	5	9
4	Indian NAL	1	2	3	4	5	9
5	French ONERA reports	1	2	3	4	5	9
6	German DFVLR, DLR, and MBB reports . . .	1	2	3	4	5	9
7	Japanese NAL reports	1	2	3	4	5	9
8	Russian TsAGI reports	1	2	3	4	5	9
9	Dutch NLR reports	1	2	3	4	5	9
10	U.S. NASA reports	1	2	3	4	5	9

42. Your native language:

_____ Please specify

43. How well do you read the following languages: (Circle numbers)

		Passably				Fluently	Do not Read This Language
1	English	1	2	3	4	5	9
2	French	1	2	3	4	5	9
3	German	1	2	3	4	5	9
4	Japanese	1	2	3	4	5	9
5	Russian	1	2	3	4	5	9
6	Other (please specify) _____						

44. How well do you speak the following languages: (Circle numbers)

		Passably				Fluently	Do not Speak This Language
1	English	1	2	3	4	5	9
2	French	1	2	3	4	5	9
3	German	1	2	3	4	5	9
4	Japanese	1	2	3	4	5	9
5	Russian	1	2	3	4	5	9
6	Other (please specify) _____						

These data will be used to determine whether people with different backgrounds have different technical communication practices.

45. Sex:

1. Female

2. Male

Over (please) ——▶

46. Education:
    1. No degree
    2. Bachelor
    3. Master
    4. Doctorate
    5. Other (specify) _____

47. Years of professional aerospace work experience:

    _____ years

48. Type of organization where you work: (Circle ONLY ONE number)
    1. Academic
    2. Industrial
    3. Not-for-profit
    4. Government
    5. Other (specify) _____

49. Which of the following BEST describes your primary professional duties? (Circle ONLY ONE number)

    01 Research
    02 Administration/Mgt
    03 Design/Development
    04 Teaching/Academic (may include research)
    05 Manufacturing/Production
    06 Private consultant
    07 Service/Maintenance
    08 Marketing/Sales
    09 Other (specify) _____

50. Was your academic preparation as an:
    1. Engineer
    2. Scientist
    3. Other (specify) _____

51. In your present job, do you consider yourself primarily an:
    1. Engineer
    2. Scientist
    3. Other (specify) _____

52. Are you a member of a professional (national) engineering, scientific, or technical society?
    1. Yes
    2. No

APPENDIX D
U.S. SURVEY INSTRUMENT
Technical Communications in Aerospace: An International Perspective

An Exploratory Study Conducted at the NASA Langley Research Center

Phase 4 of the Aerospace Knowledge Diffusion Research Project

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1. In your work, how important is it for you to communicate (e.g., producing written materials or oral discussions) technical information effectively? (Circle number)

   Very Unimportant   1   2   3   4   5   Very Important

2. In the past 6 months, about how many hours did you spend each week communicating technical information?

   (output) ____ hours per week writing

   ____ hours per week communicating orally

3. In the past 6 months, about how many hours did you spend each week working with technical information received from others?

   (input) ____ hours per week working with written information

   ____ hours per week receiving information orally

4. Compared to 5 years ago, how has the amount of time you have spent **communicating** technical information changed? (Circle number)

   1. Increased
   2. Stayed the same
   3. Decreased

5. As you have advanced professionally, how has the amount of time you have spent working with technical information **received from others** changed? (Circle number)

   1. Increased
   2. Stayed the same
   3. Decreased

6. What percentage of your written technical communications involve:

Writing alone   __%   ⟶ (If 100% alone, skip to question 9.)

Writing with one other person   __%

Writing with a group of 2 to 5 persons   __%

Writing with a group of more than 5 persons __%

100%

7. In general, do you find writing as part of a group more or less productive (i.e., quantity/quality) than writing alone? (Circle number)

1. A group is less productive than writing alone

2. A group is about as productive as writing alone

3. A groups is more productive than writing alone

4. Difficult to judge; no experience preparing technical information

8. In the past 6 months, did you work with the same group of people when producing written technical communications? (Circle number)

1. Yes ⟶ About how many people were in the group: _____number of people

2. No ⟶ With about how many groups did you work: _____number of groups

   ↓

   About how many people were in each group: _____number of people

9. Approximately how many times in the past 6 months did you write or prepare the following alone or in a group? (If in a group, how many people were in each group?)

Times in Past 6 Months Produced

	Alone	In a group	
a. Abstracts	___times	___times	___Average No. of people
b. Journal articles	___	___	___
c. Conference/Meeting papers	___	___	___
d. Trade/Promotional literature	___	___	___
e. Drawings/Specifications	___	___	___
f. Audio/Visual materials	___	___	___
g. Letters	___	___	___
h. Memoranda	___	___	___
i. Technical proposals	___	___	___
j. Technical manuals	___	___	___
k. Computer program documentation	___	___	___
l. AGARD technical reports	___	___	___
m. U.S. Government technical reports	___	___	___
n. In-house technical reports	___	___	___
o. Technical talks/Presentations	___	___	___

10. Approximately how many times in the past 6 months did you **use** the following?

   a. Abstracts   __Times used in 6 months

   b. Journal articles   —

   c. Conference/Meeting papers   —

   d. Trade/Promotional literature   —

   e. Drawings/Specifications   —

   f. Audio/Visual materials   —

   g. Letters   —

   h. Memoranda   —

   i. Technical proposals   —

   j. Technical manuals   —

   k. Computer program documentation   —

   l. AGARD technical reports   —

   m. U.S. Government technical reports   —

   n. In-house technical reports   —

   o. Technical talks/Presentations   —

11. What types of technical information do you *USE* in your present job? (Circle appropriate numbers)

	Yes	No
Basic scientific and technical information	1	2
Experimental techniques	1	2
Codes of standards and practices	1	2
Computer programs	1	2
Government rules and regulations	1	2
In-house technical data	1	2
Product and performance characteristics	1	2
Economic information	1	2
Technical specifications	1	2
Patents	1	2

12. What types of technical information do you *PRODUCE* (or expect to produce) in your present job? (Circle appropriate number)

	Yes	No
Basic scientific and technical information	1	2
Experimental techniques	1	2
Codes of standards and practices	1	2
Computer programs	1	2
Government rules and regulations	1	2
In-house technical data	1	2
Product and performance characteristics	1	2
Economic information	1	2
Technical specifications	1	2
Patents	1	2

15. Have you ever taken a course in technical communications/writing? (Circle the appropriate number)

1. Yes, as an undergraduate ⟶
2. Yes, after graduation
3. Yes, both
4. Presently taking
5. No
↓

16. How much did this course help you to communicate technical information? (Circle the appropriate number)

↓

1. A lot
2. A little
3. Not at all

17. Do you think that undergraduate aerospace engineering and science students should take a course in technical communications? (Circle the appropriate number)

1. Yes

2. No

3. Don't know

If you answered "no" or "don't know" to Question 17, please skip to Question 21. If you answered "yes" to Question 17, please continue to Question 18.

18. Do you think a technical communications course for undergraduate aerospace engineering and science students should be: (Circle the appropriate number)

1. Taken for credit

2. Not taken for credit

3. Don't know

If you answered "not taken" or "don't know" to Question 18, please skip to Question 21. If you answered "taken" to Question 18, please answer Question 19.

19. Do you think the technical communications course should be: (Circle the appropriate number)

    1. Taken as part of a required course

    2. Taken as part of an elective course

    3. Don't know

If you think the technical communications course should be taken as a separate course, please answer Question 20. Otherwise, please skip to Question 21.

20. Do you think the technical communications course should be: (Circle the appropriate number)

    1. Taken as part of an engineering course

    2. Taken as a separate course

    3. Taken as part of another course

    4. Don't know

21. Which of the following **principles** should be included in an undergraduate technical communications course for aerospace engineers and scientists? (Circle the appropriate numbers)

	Yes	No
Defining the purpose of the communication	1	2
Assessing the needs of the reader	1	2
Organizing information	1	2
Developing paragraphs (introductions, transitions, and conclusions)	1	2
Writing sentences	1	2
Notetaking and quoting	1	2
Editing and revising	1	2
Choosing words (avoiding wordiness, jargon, slang, sexist terms)	1	2
Other (specify) _____		

22. Which of the following **mechanics** should be included in an undergraduate technical communications course for aerospace engineers and scientists? (Circle the appropriate numbers)

	Yes	No
Abbreviations	1	2
Acronyms	1	2
Capitalization	1	2
Numbers	1	2
Punctuation	1	2
References	1	2
Spelling	1	2
Symbols	1	2
Other (specify) _____		

23. Which of the following on-the-job skills should be included in an undergraduate technical communications course for aerospace engineers and scientists? (Circle the appropriate numbers)

	Yes	No
Abstracts	1	2
Letters	1	2
Memoranda	1	2
Technical instructions	1	2
Journal articles	1	2
Conference/Meeting papers	1	2
Literature reviews	1	2
Technical manuals	1	2
Newsletter/newspaper articles	1	2
Oral (technical) presentations	1	2
Technical specifications	1	2
Technical reports	1	2
Use of information sources	1	2

Other (specify) _____

24. Do you use computer technology to prepare technical information? (Circle the appropriate number)

1. Always
2. Usually
3. Sometimes
4. Never

If you answered "never" to Question 24, please skip to Question 27, otherwise, please answer Question 25.

25. How much computer technology increased your ability to communicate technical information? (Circle the appropriate number)

1. Yes, a lot
2. Yes, a little
3. No, not really
4. No, not at all

26. Do you use any of the following software to prepare written technical information? (Circle the appropriate numbers)

	Yes	No
Word processing	1	2
Outliners and prompters	1	2
Grammar and style checkers	1	2
Spelling checkers	1	2
Thesaurus	1	2
Business graphics	1	2
Scientific graphics	1	2
Desktop publishing	1	2

27. How do you view your use of the following electronic/information technologies in communicating technical information? (Circle the appropriate number)

Information Technologies	I already use it	I don't use it, but may in the future	I don't use it and doubt if I will
Audio tapes and cassettes	1	2	3
Motion picture film	1	2	3
Video tape	1	2	3
Desk top/electronic publishing	1	2	3
Computer cassette/cartridge tapes	1	2	3
Electronic Mail	1	2	3
Electronic bulletin boards	1	2	3
FAX or TELEX	1	2	3
Electronic data bases	1	2	3
Video conferencing	1	2	3
Teleconferencing	1	2	3
Micrographics & microforms	1	2	3
Laser disc/video disc/CD-ROM	1	2	3
Electronic networks	1	2	3

28. At your work place, do you use electronic networks in performing your present duties?

1. Yes

2. No

3. No because I do not have access to electronic networks

If you answered "no" to Question 28, please skip to Question 34. If you answered "yes" to Question 28, please continue to Question 29.

29. At your work place, how do you access electronic networks?

1. By using a mainframe terminal

2. By using a personal computer

3. By using a workstation

30. How important is the use of electronic networks to performing your present duties?

Very Unimportant   1   2   3   4   5   Very Important

31. Based on a 40-hour work week, what percentage of your time do you use electronic networks?

_____Percentage of the past work week

32. Do you use electronic networks for the following purposes?

	Yes	No
1. To connect to geographically distant sites	1	2
2. For electronic mail	1	2
3. For electronic bulletin boards or conferences	1	2
4. For electronic file transfer	1	2
5. To log into remote computers for such things as computational analysis or to use design tools	1	2
6. To control remote equipment such as laboratory instruments or machine tools	1	2
7. To access/search the library's catalogue	1	2
8. To order documents from the library	1	2
9. To search electronic data bases (e.g., RECON)	1	2
10. For information search and data retrieval	1	2
11. To prepare scientific and technical papers which colleagues at geographically distant sites	1	2

33. Do you exchange electronic messages or files with:

	Yes	No
1. Members of your work group	1	2
2. Other people in your organization (at the same geographic site) who are not in your work group	1	2
3. Other people in your organization (at a geographically different site) who are not in your work group	1	2
4. People outside of your organization	1	2

34. How likely would you be to use the following information if it was available in electronic format?

	Very Unlikely				Very Likely
1. Data tables/mathematical presentations	1	2	3	4	5
2. Computer program listings	1	2	3	4	5
3. Online system (with full text and graphics) for NASA technical papers	1	2	3	4	5
4. CD-ROM system (with full text and graphics) for NASA technical reports	1	2	3	4	5

35. Which of the following best explains why you would not be using these materials in electronic format?

1. No/limited computer access

2. Hardware/software incompatibility

3. Prefer printed format

4. Other (specify) _____

36. Does your organization have a library/technical information center? (Circle the appropriate number)

    1. Yes, in my building

    2. Yes, but not in my building ⟶ ___Miles

    3. No

If you answered "yes" to Question 36, please continue to Question 37. If you answered "no" to Question 36, please skip to Question 39.

37. In the past six months, about how often did you use your organization's library/technical information center?

    _____Number of times in past 6 months

38. In terms of performing your present professional duties, how important is your organization's library/technical information center? (Circle the appropriate number)

Not at all important   1   2   3   4   5   Very important

39. When faced with solving a technical problem, which of the following sources do you usually consult?

    ↑

Please sequence these items (e.g., #1, #2, #3, #4, #5) or put an X beside the steps you did not use.

Sequence

    _____Used my personal store of technical information, including sources I keep in my office

    _____Spoke with co-workers or people inside by organization

    _____Spoke with colleagues outside my organization

    _____Spoke with a librarian or technical information specialist

    _____Used literature resources (e.g., conference papers, journals, technical reports) found in my organization's library)

(If you used none of the above steps, check here____.)

These data will be used to determine whether people with different backgrounds have different technical communication practices.

40. Sex:

    1. Female

    2. Male

41. Education:
    1. No degree
    2. Bachelors
    3. Masters
    4. Doctorate
    5. Other (specify) _____

42. Years of professional aerospace work experience:

    ___years

43. Type of organization where you work: (Circle ONLY ONE number)

    1. Academic
    2. Industrial
    3. Not-for-profit
    4. Government
    5. Other (specify) _____

44. Which of the following BEST describes your primary professional duties? (Circle ONLY ONE number)

    01 Research
    02 Administration/Mgt
    03 Design/Development
    04 Teaching/Academic (may include research)
    05 Manufacturing/Production
    06 Private consultant
    07 Service/Maintenance
    08 Marketing/Sales
    09 Other (specify) _____

45. Was your academic preparation as an:

    1. Engineer
    2. Scientist
    3. Other (specify) _____

46. In your present job, do you consider yourself primarily an:

    1. Engineer
    2. Scientist
    3. Other (specify) _____

47. Are you a member of a professional (national) engineering, scientific, or technical society?

    1. Yes
    2. No

APPENDIX D
U.S. SURVEY INSTRUMENT
SUPPLEMENTAL QUESTIONS

17. Do you think that undergraduate aerospace engineering and science students should have training or course work in technical communications (e.g., technical writing/oral presentations)? (Circle the appropriate number)

    1. Yes

    2. No   ⎫
             ⎬ ⟶ STOP
    3. Don't know ⎭

    If you answered "yes" to Question 17, please answer Questions 18, 19, and 20.

18. Do you think a technical communications course for undergraduate aerospace engineering and science students should be: (Circle the appropriate number)

    1. Taken for academic credit

    2. Not taken for academic credit

    3. Don't know

19. Do you think the technical communications course should be: (Circle the appropriate number)

    1. Taken as part of a required course

    2. Taken as part of an elective course

    3. Don't know

20. Do you think the technical communications course should be: (Circle the appropriate number)

    1. Taken as part of an engineering course (e.g., Engineering 201)

    2. Taken as a separate course (e.g., Technical Writing 101)

    3. Taken as part of another course (i.e., neither Engineering or English)

    4. Don't know

40. Do you use the following technical reports in performing your present professional duties? (Circle numbers)

		Yes	No	Don't Have Access
1	AGARD reports	1	2	9
2	British ARC and RAE reports	1	2	9
3	ESA reports	1	2	9
4	Indian NAL	1	2	9
5	French ONERA reports	1	2	9
6	German DFVLR, DLR, and MBB reports . .	1	2	9
7	Japanese NAL reports	1	2	9
8	Russian TsAGI reports	1	2	9
9	Dutch NLR reports	1	2	9
10	U.S. NASA reports	1	2	9

41. How important are these reports in performing your present professional duties? (Circle numbers)

		Very Unimportant				Very Important	Don't Have Access
1	AGARD reports	1	2	3	4	5	9
2	British ARC and RAE reports	1	2	3	4	5	9
3	ESA reports	1	2	3	4	5	9
4	Indian NAL	1	2	3	4	5	9
5	French ONERA reports	1	2	3	4	5	9
6	German DFVLR, DLR, and MBB reports . . .	1	2	3	4	5	9
7	Japanese NAL reports	1	2	3	4	5	9
8	Russian TsAGI reports	1	2	3	4	5	9
9	Dutch NLR reports	1	2	3	4	5	9
10	U.S. NASA reports	1	2	3	4	5	9

42. Your native language:

_____ Please specify

43. How well do you read the following languages: (Circle numbers)

		Passably				Fluently	Do not Read This Language
1	English	1	2	3	4	5	9
2	French	1	2	3	4	5	9
3	German	1	2	3	4	5	9
4	Japanese	1	2	3	4	5	9
5	Russian	1	2	3	4	5	9
6	Other (please specify) _____						

44. How well do you speak the following languages: (Circle numbers)

		Passably				Fluently	Do not Speak This Language
1	English	1	2	3	4	5	9
2	French	1	2	3	4	5	9
3	German	1	2	3	4	5	9
4	Japanese	1	2	3	4	5	9
5	Russian	1	2	3	4	5	9
6	Other (please specify) _____						

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12a. DISTRIBUTION/AVAILABILITY STATEMENT

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13. ABSTRACT *(Maximum 200 words)*
As part of Phase 4 of the *NASA/DoD Aerospace Knowledge Diffusion Research Project*, two studies were conducted that investigated the technical communications practices of India and U.S. aerospace engineers and scientists. Both studies have the same seven objectives: first, to solicit the opinions of aerospace engineers and scientists regarding the importance of technical communications to their profession; second, to determine the use and production of technical communications by aerospace engineers and scientists; third, to seek their views about the appropriate content of an undergraduate course in technical communications; fourth, to determine aerospace engineers' and scientists' use of libraries, technical information centers, and on-line data bases; fifth, to determine the use and importance of computer and information technology to them; sixth, to determine their use of electronic networks; and seventh, to determine their use of foreign and domestically produced technical reports. A self-administered questionnaire was distributed to aerospace engineers and scientists at the Indian Institute of Science and the NASA Langley Research Center. The completion rates for the India and U.S. surveys were 48 and 53 percent, respectively. Responses of the India and U.S. participants to selected questions are presented in this report.

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